WETLANDS MITIGATION EVALUATION

VEGETATION STUDIES

Final Report to

The City Of Norfolk

from

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INTRODUCTION

Coastal wetlands in Virginia represent a finite resource which is being subjected to ever increasing development pressures. As a means of reducing these losses while accomodating necessary economic development, the policy of wetlands mitigation through compensation is increasingly being utilized by both regulatory agencies and developers. This practice generally involves the grading of an upland area to the appropriate elevation and planting it with wetlands vegetation to replace a marsh being lost in another area.

The technology to plant and grow marsh vegetation for this and other purposes has been well demonstrated. In as few as two growing seasons the appearance and primary productivity can be very similar to natural marshes, but the length of time necessary for them to become fully functional in an ecolgical sense is unknown (Woodhouse et al, 1974). This question remains unanswered and the need still exists to conduct both short and long term studies of planted marshes to evaluate their success at replacing the wetlands resouces being lost to development. These studies need to include not only the plant community but also the physical environment and the utilization of these areas by invertebrates, fishes, birds, and mammals (Zedler, 1984).

In an effort to address some of these questions this portion of the study was designed to 1) compare the vegetative characteristics of a man-made marsh with those of similar natural marshes and 2) investigate the role of elevation and tidal inundation in the development of the marsh.

STUDY SITES

The primary site chosen for this study is a marsh constructed by the U.S. Navy in an old spoil disposal area called Monkey Bottom adjacent to Willoughby Bay in Norfolk, Virginia (Fig. 1). As a condition of the permit to reuse the disposal area, the Navy was required to replace 7.6 acres of tidal wetlands which had developed in the center of the disposal area (Priest et al, 1982).

The new tidal wetland was designed for a parcel of the disposal area adjacent to a four foot diameter culvert under the I-64 causeway that connected the area to Willoughby Bay. Because of the extensive stands of common reed, Phragmites australis, present in the disposal area, the new marsh was designed to support saltmarsh cordgrass, Spartina alterinflora, at and below the elevation of mean high water. It was hoped that this low design elevation would prevent the colonization of the compensation area by common reed.

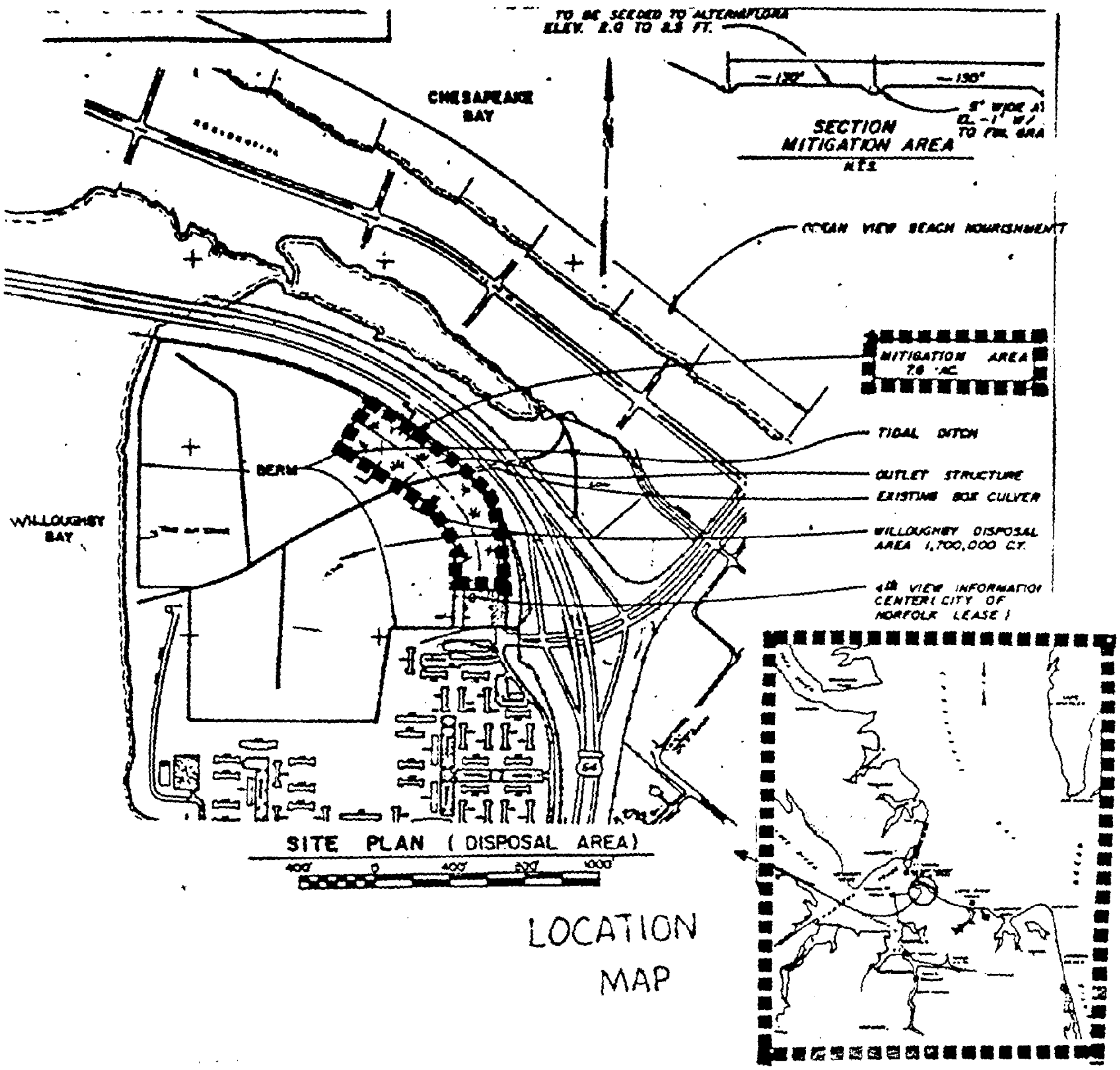

Figure 1. Location of Monkey Bottom Disposal Area

Construction of the marsh began in the summer of 1984 concurrent with the construction of the berm for the new disposal area. The compensation area was graded to elevations at and below mean high water. Drainage was accomplished by sloping the area to four lateral ditches which emptied into the main ditch that connected to the culvert under I-64 (Fig. 2). During the grading and planting, the area was isolated from tidal inundation.

The marsh was planted with saltmarsh cordgrass, Spartina alterniflora, during September and October 1984, using a tree planter. The two sections closest to the City of Norfolk Visitor's Center were planted on two foot centers with transplants from the site. The two sections furthest from the Visitor's Center were planted with six month old seedlings also on two foot centers. The entire area was broadcast with an especially prepared 19-5-12 slow release fertilizer at the rate of one ounce per planting. The fertilizer was mechanically raked into the soil prior to planting. The entire area was planted, even areas above and below the expected successful elevation, so that good coverage was ensured.

The natural marshes used for comparison were a small pocket marsh on Willoughby Bay (Willoughby Bay) (Fig. 3) adjacent to the disposal area and a a small embayed marsh on the Lafayette River (Larchmont Pond) (Fig. 4). The natural comparison marshes were selected on the basis of proximity to the planted marsh, similar physiography and hydrology and plant communities which appeared similar in composition.

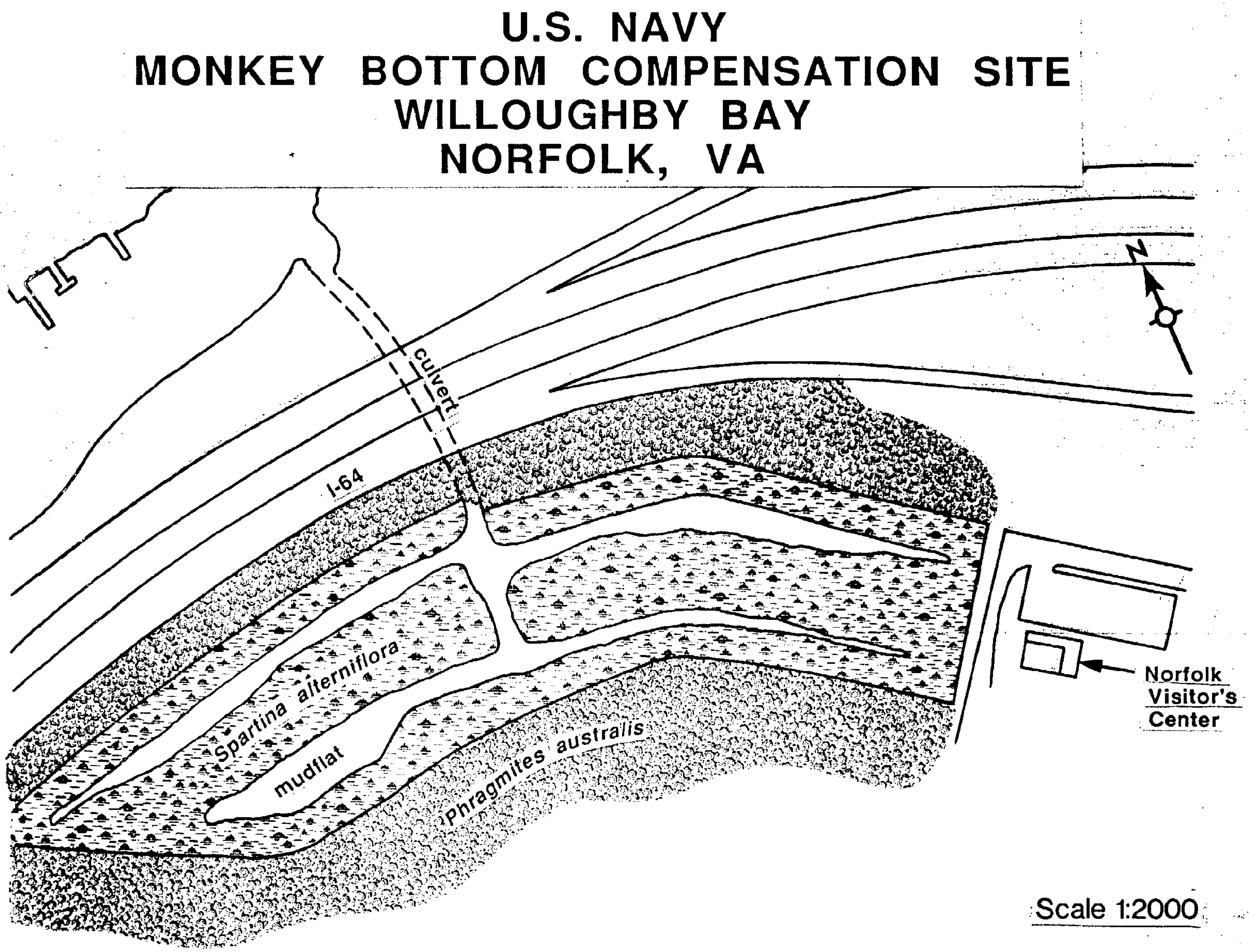

Figure 2. Monkey Bottom Marsh study site

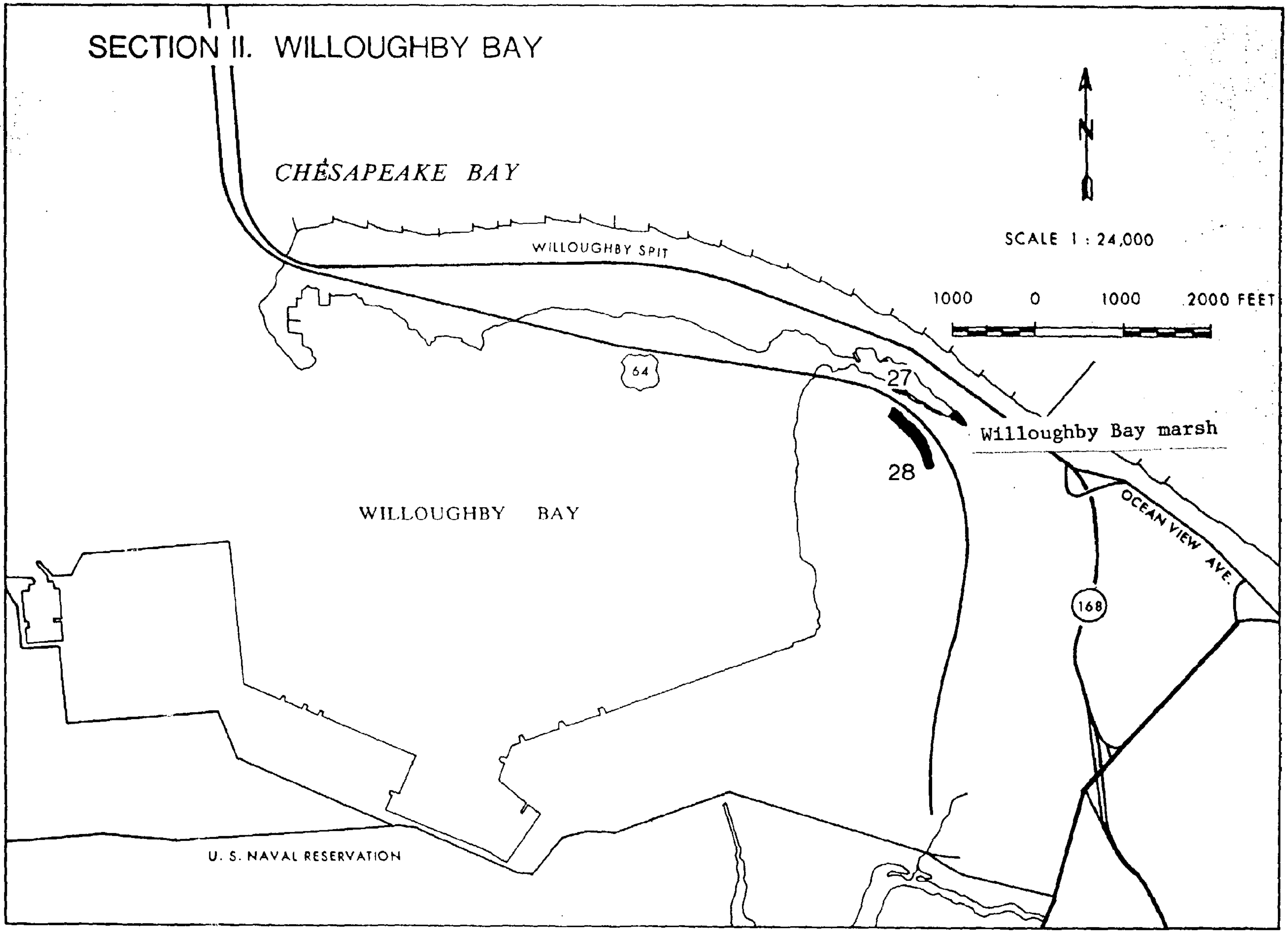

Figure 3. Location of Willoughby Bay study site

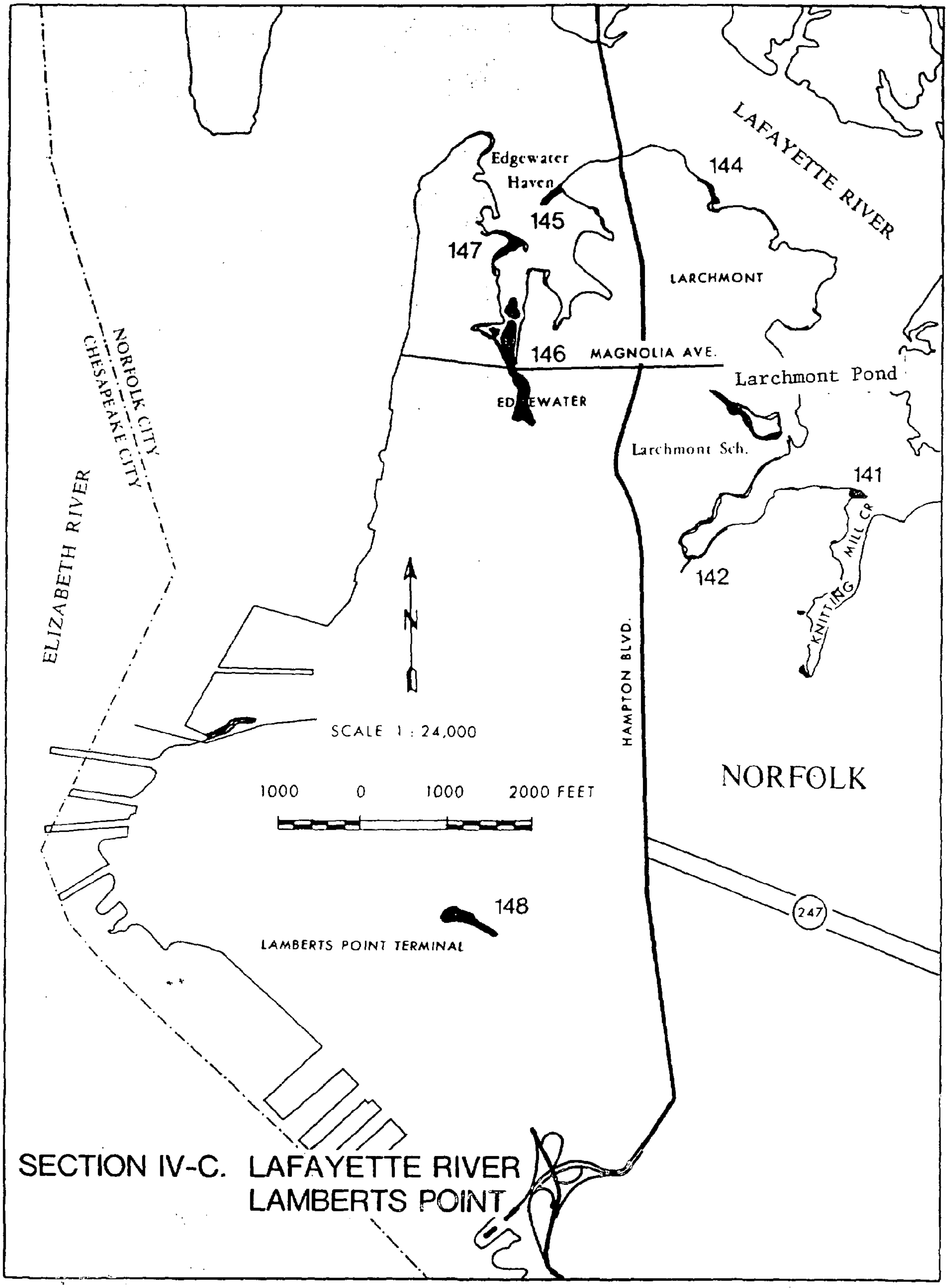

Figure 4. Location of Larchmont Pond study site

METHODS

At Monkey Bottom the transects were established along the centerline of each lateral ditch. The sampling plots were selected by a random distance along the centerline and a random distance to one side or the other. At the Willoughby Bay and Larchmont Pond sites the centerline line transect was established down the center of the marsh and the plots randomly selected in the same manner as at Monkey Bottom.

Each plot was sampled with a .25 m^2 square circular quadrat for cover, density and peak standing crop. Percent cover for each species within the quadrat was visually estimated. All of the stems within each quadrat were counted and clipped at ground level to determine stem density. The clipped stems were put in plastic trash bags and returned to the laboratory. The samples were washed lightly to remove extraneous inorganic material and oven dried to a constant weight to determine the estimate of peak standing crop.

The center of each quadrat was marked with a stake which was used as a reference point in determining the elevation of the quadrat. This was done by a surveying crew from the City of Norfolk. The surveying crew also provided the elevations of the upper transition zone between the cordgrass and the common reed, Phragmites australis, the lower limit of the cordgrass, the ditch bottom and the ridge between the marsh sections at Monkey Bottom. They also obtained the quadrat elevations, upper transition zone and lower cordgrass limits at Larchmont Pond. Only the quadrat elevations were obtained at the Willoughby Bay site. At Monkey Bottom and Willoughby Bay, the elevations were related to the tidal survey performed by ODU for this study. At Larchmont Pond the elevations were related to available NOS data.

RESULTS

A summary of the vegetation characteristics measured at the three study sites is presented in Table 1 and graphically depicted in Figure 5.

The highest average percent cover was 64% at Willoughby Bay, Larchmont Pond followed with 58% and Monkey Bottom was third with 46%. At Monkey Bottom and Willoughby Bay the only species present in the quadrats was *Spartina alterniflora*. The Larchmont Pond quadrats included the perennial saltmarsh aster, *Aster tenuifolius*, within the cover estimates where it represented 9% of the reported 58% total cover.

Stem density was highest at the Larchmont Pond site with $465/m^2$. Monkey Bottom was next with a density of $340/m^2$. Willoughby Bay had the lowest stem density with $308/m^2$. As with the cover estimates, the densities at Willoughby Bay and Monkey Bottom were strictly *Spartina alterniflora*. In the quadrats at Larchmont Pond the *Aster tenuifolius* density averaged $92/m^2$ out of the average total density of $465/m^2$.

Table 1. Summary of the vegetation data for the three study sites (Cover= %, Density= stems/m^2, Standing Crop= g/m^2, Elevation= MLW).

MONKEY BOTTOM

	Mean	Std Dev	Min	Max	N
Cover	45.73	28.55	0	85	26
Density	340.00	220.42	0	744	26
Standing Crop	591.43	392.45	0	1119.68	26
Elevation	1.54	.40	.96	2.43	24

WILLOUGHBY BAY

	Mean	Std Dev	Min	Max	N
Cover	64.17	13.57	40	80	6
Density	308.00	112.74	180	456	6
Standing Crop	559.18	213.32	176.0	769.52	6
Elevation	2.01	.18	1.75	2.23	5

LARCHMONT POND

	Mean	Std Dev	Min	Max	N
Cover	57.86	13.18	40	80	7
Density	464.57	87.95	392	648	7
Standing Crop	448.10	144.38	263.9	712.64	7
Elevation	2.60	.12	2.37	2.74	7

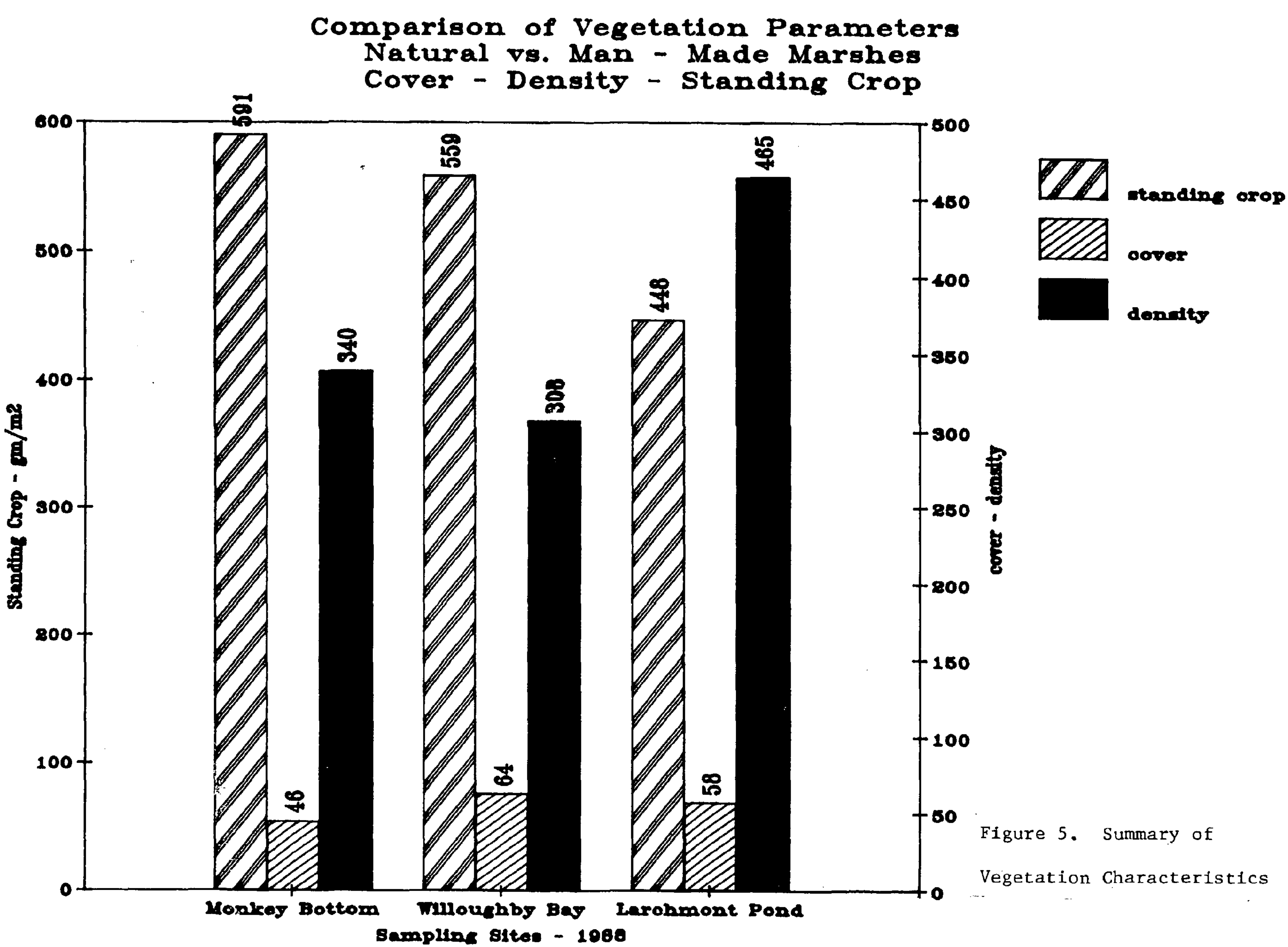

Figure 5. Summary of Vegetation Characteristics

The highest average peak standing crop of organic matter, 591.43 g/m^2 was found at Monkey Bottom. The next highest was 559.18 g/m^2 at Willoughby Bay. The lowest value, 448.10 g/m^2, was found at Larchmont Pond. The Aster tenuifolius found in the quadrats at Larchmont Pond was not analyzed separately and is included with the Spartina alterniflora standing crop.

After being tested for normal distribution, homogeneity and additivity, an analysis of variance was performed comparing cover, density and standing crop among the three sites. The results indicated that no two groups were significantly different at the .05 level (Table 2).

Table 2. Results of the One Way Analysis of Variance of the Vegetation Data Among the Three Study Sites.

	F ratio	F prob
Standing crop	4.853	.6195
Density	1.399	.2601
Cover	1.683	.2002

The data was also analyzed using the Pearson Correlation Coefficient to determine any relationships between the measured variables and elevation at each of the three sites (Table 3). The data indicate that at Monkey Bottom there is a significant positive correlation between elevation and cover, density and standing crop. At the two natural control sites, however, there

Table 3. Pearson Correlation Coefficients for elevation vs. vegetation parameters at the three study sites.

MONKEY BOTTOM

		Cover	Density	Standing Crop
Elevation	R2	.6080	.3985	.6292
	N	(24)	(24)	(24)
	P	.001	.028	.000

WILLOUGHBY BAY

Elevation	R2	-.4207	.6734	.7965
	N	(5)	(5)	(5)
	P	.240	.106	.053

LARCHMONT POND

Elevation	R2	-.2140	.3805	.2691
	N	(7)	(7)	(7)
	P	.322	.200	.280

was no significant correlation between any of the vegetation characteristics measured and elevation.

The quadrats at Monkey Bottom had the lowest average elevation 1.54 feet MLW (mean low water) and the greatest range in elevations, 1.47 feet. The highest average elevation of quadrats was 2.6 feet MLW at Larchmont Pond as was the smallest range in elevations, .37 feet. The Willoughby Bay site was in between with an average elevation of 2.01 feet MLW and an elevation range of .48 feet.

At Monkey Bottom the average elevation of the center of the transition zone between the *Phragmites australis* and *Spartina alterniflora* was 2.68 feet MLW just slightly above the mean high water (MHW) elevation of 2.47 feet. The average lower elevation of the *Spartina alterniflora* was 1.20 feet which was almost exactly the mean tide level (MTL) of 1.23 feet for the 2.47 foot tide range at the site.

DISCUSSION

Even though there were no significant differences among the marshes studied, a number of reasons for the observed differences became apparent during the course of the analysis of the data. Cover was higher at the two natural marshes partly because the open areas of Monkey Bottom were a more prominent feature of the sample site and consequently more frequently sampled. Whereas the two comparison marshes had little or no naturally non-vegetated areas and the creek adjacent to the Larchmont Pond site did not happen to get sampled during the study. If the empty quadrats are removed from the Monkey Bottom cover estimates the percent cover increases to 54% compared to 64% for Willoughby Bay and 58% for Larchmont Pond.

The high density values at the Larchmont Pond were attributable to a large degree to the presence of a large number of mature plants as well as numerous seedlings of Aster tenuifolius among the dominant Spartina alterniflora.

The fact that the standing crop was higher at Monkey Bottom was probably due in large measure to the range of elevations sampled, particularly the lower, taller, more productive portions of the marsh (Lefors et al., 1987). A comparable range of elevations was inadvertently either not sampled or not available at the natural sites. Also, none of the Monkey Bottom samples was above MHW where at Larchmont Pond most of the samples were taken at or above MHW in normally less productive portions of a Spartina alterniflora marsh.

The fact that there were no correlations between elevation and the vegetation parameters in the natural marshes is probably due to the fact that they have a much narrower range of elevations (flatter) and are generally at higher elevations. The variability that a man-made marsh can introduce into a system can tend to provide a more diverse habitat than some similar natural systems with less variability. However, future efforts in marsh comparisons should require not only marshes of similar species composition but also those with a similar elevation and range of elevations to eliminate some unnecessary variability from the comparisons.

When comparing data on the production of marshes, the ranges of values is trremendous. Keefe (1972) repots production values for Spartina _alterniflora_ ranging from 250-2100 g/m^2. This would put the values from this study, 448-591g/m^2, among the lower quarter of that range. However when compared to values from Oviatt et al. (1977), 450-980 g/m^2, they fall in the lower half of that range. Density values for the same marshes from Oviatt et al. (1977) ranged from 230-1170 stems/m^2 as compared to the range of 308-465 stems/m^2 in this study.

When the Monkey Bottom marsh was designed, the elevations of the area to be planted with _Spartina_ _alterniflora_ were kept below MHW (2.47 feet MLW) under the premise that _Phragmites_ _australis_ would not grow below MHW in mesohaline areas. If true, this might prove to be an effective means of preventing the encroachment of this weedy undesirable species into compensation areas and displacing the planted species (Silberhorn et al. 1974). At least in this instance, this design criteria appeared to be appropriate because the average elevation of the transition zone between the _Spartina_ _alterniflora_ and the _Phragmites_ _australis_ was 2.68 feet above MHW. Furthermore, no _Phragmites_ _australis_ was found within any of the quadrats sampled.

The average lower limit of _Spartina_ _alterniflora_ of 1.2 feet MLW or .03 feet below MTL is also an important design criteria for planting marshes. These two elevations, MTL and MHW, in this instance, defined the effective lower and upper limits for planting saltmarsh cordgrass.

CONCLUSION

Whenever natural systems are studied, their natural variability makes comparisons between sites difficult. And indeed, considerable variability was found in the three marshes studied in this report. Monkey Bottom had the highest standing crop but the lowest percent cover. Willoughby Bay had the highest percent cover but the lowest density. Larchmont Pond had the highest density but the lowest standing crop. Despite this variability in cover, density and standing crop there were no statistically significant differences in these parameters among the three marshes.

When compared with literature values for similar types of natural marshes, all were near the lower ends of published ranges for density and standing crop but still within the range of natural variability.

While not necessarily as productive as some other marshes, the Monkey Bottom plant community appears to be a viable and productive component of the estuarine system.

The design criteria of planting *Spartina alterniflora* between MTL and MHW in mesohaline areas to successfully compete with *Phragmites australis* appears to be confirmed.

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